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Critical Fire Weather Patterns. . .

their frequency and levels of fire danger

Melvin K. Hull
Clyde A. O'Dell
Mark J. Schroeder

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CRITICAL FIRE WEATHER PATTERNS--

THEIR FREQUENCY AND LEVELS OF

FIRE DANGER

by

Melvin K. Hull, Forest Service, U. S. D. A.
Clyde A. O'Dell, Weather Bureau, E. S. S. A.
Mark J. Schroeder, Weather Bureau, E. S. S. A.

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FOREWORD

In March 1962, a contract was made between the Office of Civil Defense, Office of the Secretary of the Army, and the U. S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. It stated that the Forest Service "shall ascertain the major weather patterns producing critical fire weather nationwide and establish criteria for estimating their effect on mass fires in major target areas following large-area ignition by nuclear attack."

The first part of the objective--to identify weather patterns associated with critical fire weather--was met in a report published in 1964.[1] Results of a study to meet the second part of the objective are reported in this publication. The probable effect on fire behavior of weather associated with the synoptic types was established through the use of fire danger indexes. We determined the levels of fire danger, using the indexes, for each fire weather pattern, and thus estimated the relative influence of each pattern on fire behavior.

The area covered and the data used in this paper were the same as those for the previous report. The area consists of the 48 contiguous States divided into 14 regions of the United States. The data used were each month of a 10-year period (1951-60) for a nationwide network of 89 weather stations.

This report describes the subjective methods used to classify the patterns and explains the methods used to process the large volume of data. It also summarizes results of the study, and suggests applications.

Fire danger indexes and weather elements for the 89 stations have been assembled in 13 separately bound supplements that can be purchased from the Clearinghouse for Federal Scientific and Technical Information, U. S. Department of Commerce, Springfield, Virginia 22151. Copies of this and the earlier report also may be purchased from the Clearinghouse.

1/Schroeder, Mark J. et al. Synoptic weather types associated with critical fire weather. Berkeley, Calif. Pacific SW. Forest & Range Exp. Sta., U. S. Forest Serv. 492 pp., illus. 1964.

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The tables listed below summarize the frequency and duration of the weather types and patterns, by months, for the years 1951-1960.

Summary

Weather is one of the dominant factors responsible for uncontrollable spread of mass fires in both urban and rural areas. Identification of the weather types causing critical burning conditions in 14 contiguous regions of the United States was the subject of the previous report.[2/] But to be of much practical value, knowing what the critical weather types are and where they influence burning conditions adversely is not enough. We must also know when they will occur and the type of weather and burning conditions that can be expected. This study is a step in that direction.

Ten years of synoptic weather maps (1951-1960) were studied to determine the frequency of occurrence of each of 21 critical fire-weather types, by months, on a year-round basis. Next, various statistics were computed showing mean values and variations of weather parameters and fire danger indexes, by type and month, at each of a network of 89 representative cities. Using these data as a climatology reference, fire-weather forecasters should be able to make a first approximation probability statement about the occurrence of a particular weather event.

[2/] Schroeder, Mark J., et al. Synoptic weather types associated with critical fire weather. U. S. Forest Serv., Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif., 492 pp., illus. 1964.

METHODS

Classifying Fire Weather Types

The critical fire-weather types were selected from either the Northern Hemisphere Synoptic Weather Series maps or U. S. Weather Bureau Analysis Center micro-film copies for the period 1951 through 1960. Each type was projected forward in time and space from morning charts to coincide with the early afternoon weather observation for each city selected. Guidelines were set up to maintain continuity in the selection of cases and to provide for such problems as dividing high pressure cells, bubble Highs separating from parent Highs, merging between types, etc.. To account for differences in burning conditions, the Highs were divided into quadrants identified as post-frontal, pre-frontal, or north or south quadrants. General precipitation days were eliminated when possible by noting plotted station data, but since air-mass precipitation cannot always be determined in this way, many days with precipitation and low fire danger were included. These days could have been eliminated easily by machine, but including them gave a truer picture of the probability of high fire danger.

In the East there are four primary surface High types: Pacific, Northwest Canadian, Hudson Bay, and Bermuda Highs. In the West, there are combinations of surface and upper-air types partly because of complicated terrain. These are appropriately named. Most critical fire-weather types are associated with the anticyclonic flow in surface high pressure systems or upper-air ridges. One notable exception is the Chinook type.

Regions East of the Rockies.--There are eight regions east of the Rocky Mountains. Because of their similarities they are discussed as a group for each of the weather types affecting them. The East is affected by six critical fire-weather types. Four of them--Pacific, Northwest Canadian, Hudson Bay, and Bermuda Highs--affect all regions, while the Pacific and Canadian Chinook and Tropical Storm types affect only limited areas.

The Pacific High was by far the most prevalent of the four primary types, followed by the Northwest Canadian, Bermuda, and Hudson Bay High types. Fire danger around the periphery of the High, where pressure gradients are tighter, is higher than elsewhere. Normally as a High passed a station its eastern most quadrant (post-frontal) was followed by the south or north quadrant and then the pre-frontal quadrant. For a station to remain in each quadrant 1 or 2 days was not unusual, but, with fast moving systems, a quadrant might occasionally skip a station altogether.

The Chinook types occur along the eastern slopes of the Rockies in the western portions of the Northwest and Southern Plains Regions. They cause extreme fire danger for short periods of time. The Pacific Chinook occurrence outweighs the Canadian by about 4 to 1.

Tropical storms sometimes cause high fire danger in the area beyond the rain shield, but so few occurred that statistics were not determined for them.

Regions West of the Rockies

Northern Rockies and Northern Intermountain Region.--Two surface types affect this region: the Pacific and the Northwest Canadian Highs. Critical fire weather occurs only in their pre-frontal and post-frontal quadrants. Peaks in critical burning periods frequently occur during dry frontal passages. The presence of a thermal trough just to the west of the High enhances the flow of dry southerly surface winds around the south side of the high pressure area. The steepness of the upper-air ridge determines whether or not a Northwest Canadian High will affect this region. And the direction of the upper-air flow is the principal difference between the two fire-weather types.

Central Intermountain Region.--Upper-air flow is more significant in this region. There are three critical fire-weather types. One, an upper-air pattern, is the Meridional Ridge-Southwest Flow type; the other two types are combinations of an upper-air pattern and a surface Pacific High type. The principal difference between these two types is the direction of the upper-air flow. The stations affected in the Meridional Ridge-Southwest Flow type are under the west side of the upper ridge. In the other two types--the Pacific High-Meridional Flow and the Pacific High-Zonal Flow--the direction of the upper-air flow is northwesterly in the meridional type, while in the Zonal type the upper flow changes only slightly in direction as small amplitude waves pass by. Dry frontal passages at the surface cause peaks of relatively short duration in fire danger.

Southwest Region.--The three critical fire-weather types in the Southwest Region are the Meridional Ridge-Southwest Flow, the Short Wave Train, and the Zonal Ridge types. All three are identified on upper-air charts because the surface pressure patterns are poorly defined. The Short Wave Train pattern is quite similar to the Meridional Ridge-Southwest Flow type except that the amplitude and wave length in the "Train" pattern are much smaller. Well developed short waves are carried in the belt of westerlies through the long-wave pattern exerting their effect on fire danger by increasing wind velocities. All three types have the common characteristics of a ridge to the east and trough to the west of

the affected area. The Zonal Ridge type, however, is an extremely flat pattern with small changes in wind direction aloft.

Pacific Northwest Region.--Critical fire weather in the Pacific Northwest occurs only when flow is offshore and strong enough to force the marine air off the coast. Dry East or Northeast winds of continental origin are responsible for high fire danger. Offshore flow occurs in both Pacific and Northwest Canadian air masses, but the Pacific High type is by far the most frequent.

California Regions.--The critical fire-weather types of northern and southern California were similar and therefore the two regions were combined. Four weather types are significant--two are upper-air and two are surface types. The upper-air patterns are the Subtropical High Aloft and the Meridional Ridge-Southwest Flow. The Subtropical High is a stagnant pattern which blocks moisture from the Gulf of Mexico. Maximum temperatures are high and humidities correspondingly low. The Meridional Ridge-Southwest Flow pattern usually brings marine air and low fire danger in the coastal areas, but the higher stations and interior valleys are adversely affected by high winds when frontal passages occur to the north, tightening pressure gradients.

The Pacific High Post-Frontal and Great Basin High types produce the well-known foehn winds and their associated extreme fire danger. The combined effects of high winds and dry air produced by these weather types bring about rapid changes in burning conditions. They cause extreme fire weather which is unparalleled anywhere else in the United States.

Processing The Data

The raw data were placed on punchcards and processed on IBM 1620 and 7094 computers. The program produced statistics by station, month, and weather type. The statistics comprise the bulk of this report and are grouped both by region and station, and by critical fire-weather type. They have been published separately in the form of supplements.

RESULTS

The results of the study consist primarily of the statistics themselves. A summary of the frequency and duration of each of the major synoptic types was recorded separately in a series of tables. Statistics on weather parameters and fire danger indexes for each type were recorded for each of the 89 individual stations.

APPLICATIONS

The statistical form of this report leaves wide latitude for applying the results. We have identified three broad areas in which the results can be readily applied. The first two, fire weather forecasting

and fire control planning, are operational areas; the third area, weather and fire phenomena, can be of immediate concern to the researcher who is seeking to improve his understanding of the fire problem. We recognize the limitations of probability forecasting based on climatological data such as those included in this report, but the fact remains that we do have now a basis upon which a quantitative probability forecast for a particular event can be made. Because of the variability between years in the occurrence of each of the critical fire-weather types, the forecaster will not be relieved of the necessity of predicting the event based on present methods. These data will, however, give him a quantitative idea of what the odds are, based on climatology. The data will also be useful to a forecaster in other meaningful ways. For example, he will be able to compare one type or quadrant to another and determine how the various weather parameters change relative to one another. In this comparison he can determine which types are worse than others, and by how much, and in which months, etc.

Long range planning can be effectively carried out by fire control agencies by using the data in much the same way as the forecaster uses them. Assessing the relative potential of each fire weather type in each location should be most advantageous. Just knowing the relative differences between critical fire-weather types by months gives the fire control planner a way of quantitatively rating one area against another for any particular month in the year. By extending the statistics reported here to other stations, probability forecasts could be refined for local fire-weather areas.

CONCLUSIONS

1. Fire danger is not always high when one of the critical fire-weather types occurs; therefore the forecaster must still assess the weather situation for precipitation, temperature, and past weather since these factors cannot be readily interpreted from the synoptic charts themselves.

2. If applied intelligently, the statistics can be used effectively as an aid in forecasting specific values of several weather parameters.

3. Fire control planners should find the statistics helpful in developing long range fire plans.

Introduction

Recent wildfires in the United States emphasize again the close association between synoptic pressure patterns and severe burning conditions. During the period September 18-29, 1964, more than 200,000 acres of wildland were burned in California. Two fires accounted for two-thirds of this destruction. The Hanley fire near Calistoga burned 67,700 acres, and the Coyote fire near Santa Barbara burned 67,000 acres.[3/] Many homes were also destroyed in these fires. Synoptic types occurring during the period were the Pacific High Post-Frontal type and the Great Basin High type and were described in the previous report.

Information in this report will be useful to fire-weather meteorologists, but its usefulness is not necessarily limited to them. The advantage of having more than a casual idea about the probability of occurrence of each fire-weather type and the associated numerical values of meteorological parameters is obvious. But we expect also that fire control agencies will be able to incorporate the meteorological and fire danger factors into their long range, large scale fire planning. The principal value of this report and its supplements rests on their use as a climatological tool.

The area covered in this study is the same 14 regions of the United States (fig. 1) used in the previous report. It incorporates data for each month of a 10-year period (1951-1960) for 89 weather stations.

[3/] Senate fact finding committee on natural resources. Fire Problems of California, 1964. (Unpublished rep. on file at Pacific Southwest Forest & Range Exp. Sta., U. S. Forest Serv., Riverside, Calif.)

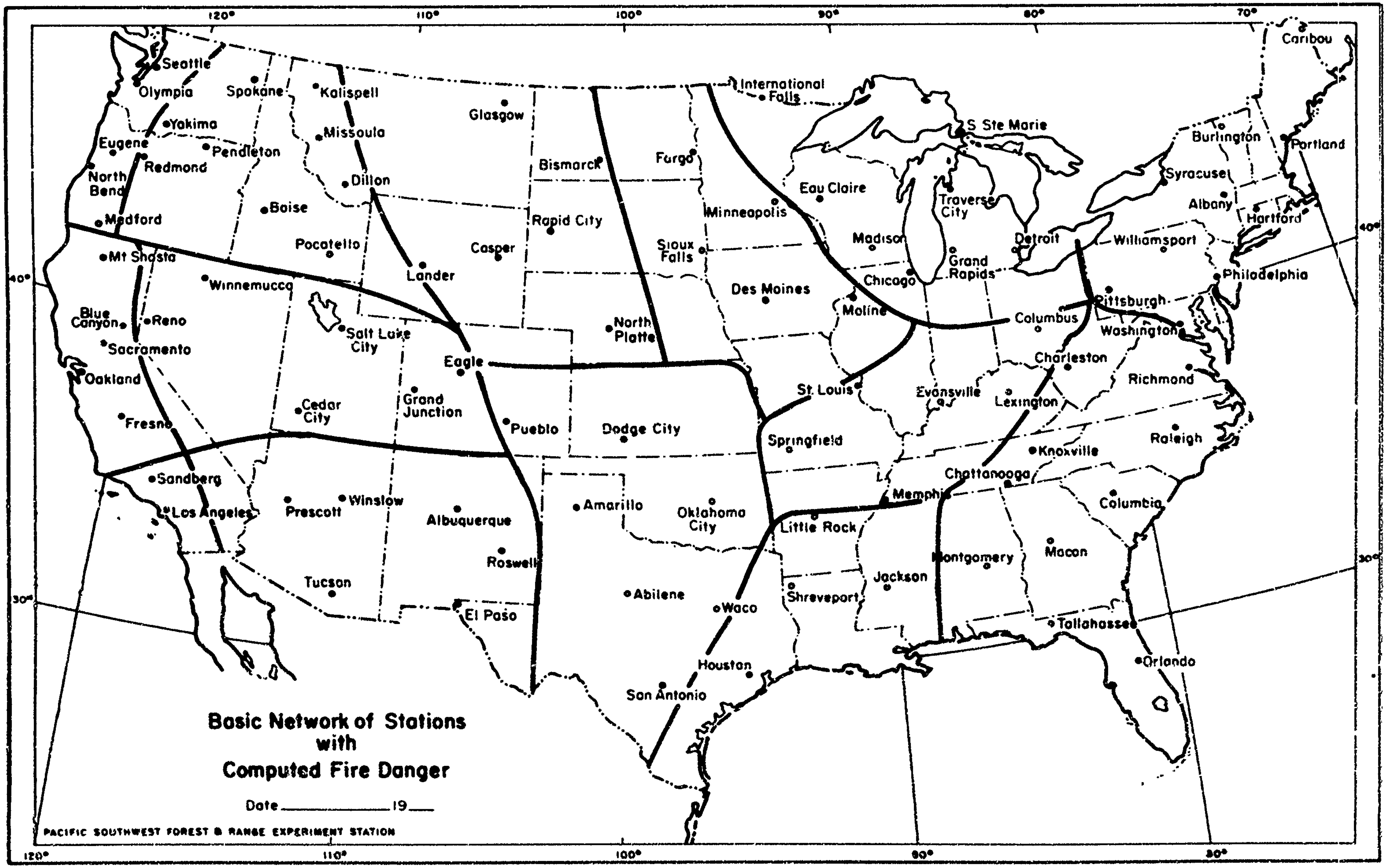

Figure 1.--The 48 contiguous States were divided into 14 regions. Data from a network of 89 weather stations were used.

Methods

CLASSIFYING FIRE-WEATHER TYPES

The Northern Hemisphere Synoptic Weather Maps for 1951 through 1960 were the primary source material for this study. These maps consist of 1200 or 1230 GMT surface and 1200 or 1500 GMT 500 mb charts. For periods when they were not available, microfilm copies of U. S. Weather Bureau Analysis Center maps were used. All critical fire-weather types described in this report were identified and recorded from these charts. The pressure patterns were projected forward in time and space each day to coincide with the time of the early afternoon weather observation (usually 1400 LST) for each city selected.

It should be pointed out here that a great deal of subjectivity was needed to identify borderline cases, and indeed to select the types themselves. We were, in fact, quite liberal in deciding whether or not a pressure pattern should be classed as a fire-weather type and thus included many low fire danger days. We used general guidelines to keep properly oriented, but at times deviated from them when we thought it necessary.

When a critical fire-weather type occurred and affected some portion of the United States,[4/] the dates of its influence on each affected station were recorded. The duration of each type over any particular station depended on how rapidly the pattern moved. Continuous dates were recorded as long as the station in question remained under direct influence of the type. Consecutive days were recorded as a single case.

Nearly all critical fire-weather types are associated with surface high pressure systems or upper-air ridges. One exception is the Chinook type, which, by definition, occurred between frontal connecting isobars in the warm sector; another exception is the dry windy area of a tropical storm circulation. Some variation in burning conditions may be expected in different portions of a surface high pressure system. To point out these differences we divided the

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[4/] This report does not include Alaska and Hawaii.

High into quadrants (fig. 2) and specified the one in which the station was located. The north and south quadrants carried the names of their respective cardinal points; the east and west quadrants were called post-frontal and pre-frontal, respectively. Occasionally we found it necessary to consider the coordinate system to be rotated slightly if the High's direction of translation was from the southwest or northwest. In this way we could maintain consistency between quadrants.

Sometimes a high pressure center divided over the United States, but did not form two separate cells. Such multi-centered cells were considered as one case. When bubbles separated from their parent Highs -- a common occurrence for the Pacific and Northwest Canadian High types--each bubble was considered a new case. The merging of Highs could not be handled quite so easily. Each time this happened the dominant High, supported by upper-air flow, was continued and the other High, which was absorbed -- so to speak-- was terminated. Another kind of merging often took place in the southeastern United States between the Bermuda High and the other three primary types: Pacific, Northwest Canadian, and Hudson Bay. As each of these three types encountered the Bermuda air mass, it retained its identity until the frontal system between them dissipated and the dewpoints at the coastal stations rose to 60° F. or greater.

Days with general precipitation were avoided when such precipitation was evident on the plotted map. Often, however, the occurrence of precipitation could not be determined. The plotted map will not always indicate whether a frontal passage is dry or wet, and it will not always indicate air mass precipitation. As a result, many days with light precipitation, and therefore low fire danger, are included.

We believe that this gives a truer picture of the probable associated weather and fire danger. The rain days could have been eliminated easily by machine processing. But this omission would result in a less reliable estimate of the probability of high fire danger when one of the fire-weather types is approaching a station or region.

Regions East of the Rockies

The regions east of the Rockies are the Northeast, Southeast, Lake States, Ohio and Middle Mississippi Valleys, West Gulf States, Southern Plains, Northeastern Plains, and Northwestern Plains. These regions are discussed as a group because most of the fire-weather patterns were similar for them.

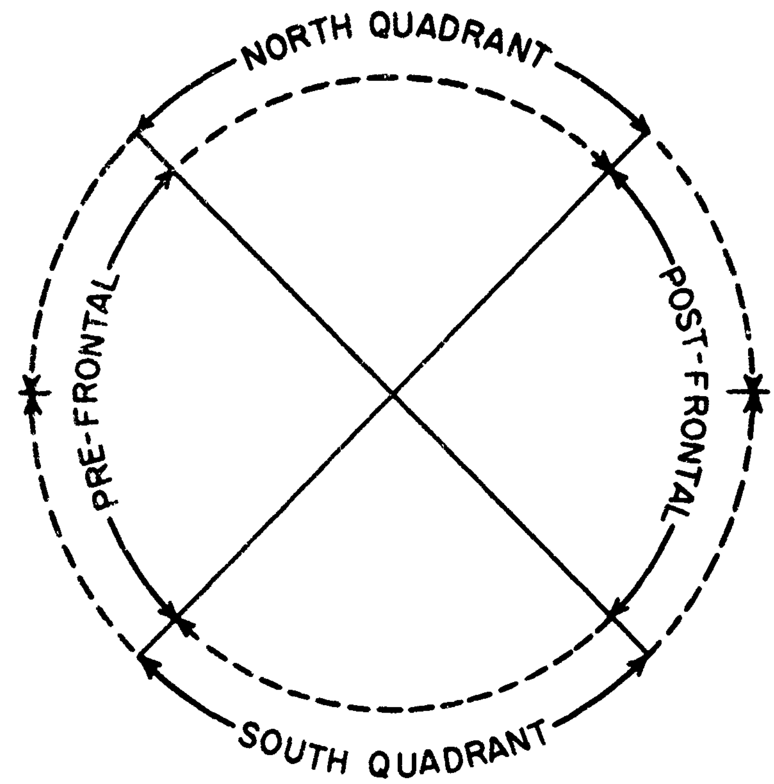

Figure 2.--Diagrammatic division of high pressure area into quadrants for the purpose of describing the location of a station within a High.

Four of the six types for the regions east of the Rockies were common to all of these regions. These were the Pacific, Northwest Canadian, Hudson Bay, and Bermuda High types (fig. 3). The other two, the Chinook and Tropical Storm, were peculiar to limited areas.

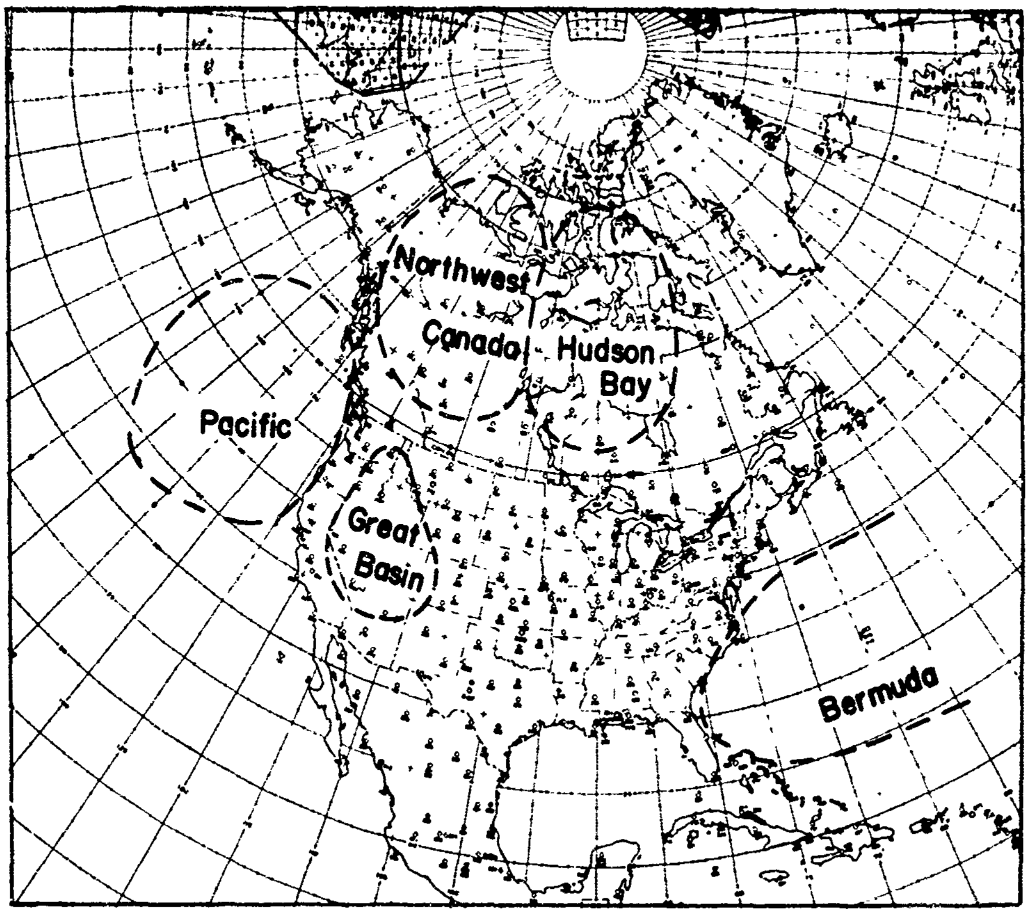

Figure 3.--Designation for origin or location of surface anticyclone.

Pacific High type.--This type originated over the Pacific Ocean and usually crossed onto the continent in the Pacific Northwest or through British Columbia (fig. 3). It usually took 3 or more days for this type to enter and affect the eastern regions. The Pacific High type was by far the most prevalent of the fire-weather patterns. Because the United States is in the belt of prevailing westerlies this was to be expected.

Post-frontal quadrant: Normally the eastern quadrant of the High was the post-frontal area. A station remained in this quadrant usually only 1 day but on occasion, with slow moving systems, 2 or more days. Sometimes the quadrant was skipped altogether when systems were moving very rapidly. High fire danger usually occurred in the tighter pressure gradients behind the front if the frontal passage was dry.

South quadrant: This quadrant usually followed the post-frontal quadrant by a day or so, when the High center was to the north or northeast and occasionally the northwest of the station. No frontal passages were involved; indeed on some occasions when the type was fast moving the post-frontal quadrant was bypassed altogether. With slow moving or stationary systems, the quadrant remained over one area for several days.

North quadrant: The north quadrant was observed the least. Highest fire danger occurred here when frontal systems or troughs passed to the north of the area, tightening the pressure gradient in the northern quadrant.

Pre-frontal quadrant: A pre-frontal quadrant was considered to be the area of the High in advance of a cold front. This quadrant was usually the western quadrant and occasionally the northwestern quadrant. A station remained in the pre-frontal area 1 or 2 days as a rule, but if the frontal system was slow moving, it remained there for several days. At times, the pre-frontal area included the warm sector of a wave, an area where the fire danger can be extremely high.

Northwest Canadian High type.--This type included Highs which originated in northwestern Canada (fig.3) and Highs which originally formed over the northern Pacific and moved inland through Alaska, then southward along the eastern side of the Canadian Rockies. The Northwest Canadian High type ranks second in number of occurrences only to the Pacific High type. Quadrant designation, nomenclature, and methods of identification are the same as those described under the Pacific High type.

Hudson Bay High type.--Hudson Bay Highs originated in the northern Ontario Province of Canada, usually east of 100° W. longitude (see fig. 3). They occurred least frequently of the four eastern types but lasted about as long as the others. The quadrants of the Hudson Bay Highs were identical to those of the previous two types.

Bermuda High type.--Characteristics of the Bermuda High type were not quite the same as the other three primary types. The air mass was primarily of maritime origin (fig. 3) and unlike its Pacific counterpart had no large mountain range in its trajectory path to deplete it of its moisture supply. Fire danger indexes were usually lower with the Bermuda High type, but on occasion the Bermuda High caused severe drought and critical fire weather. An interesting difference between the Bermuda High type and the other three (Pacific, Northwest Canadian, and Hudson Bay) was that the trajectory of the Bermuda High normally was from the east while the others were not. Quadrants of the Bermuda High were the same as the other three primary types.

Chinook type.--Chinook winds are found only along the east slope of the Rockies. Therefore, the Chinook type applied only to the western portions of the Northwest Plains and Southern Plains regions. The Chinook types were, by definition, warm sector phenomena supported by upper-air flow. Winds with westerly components were a requirement along with frontal connecting isobars. Undoubtedly this definition eliminated some Chinook types that were lost in the pre-frontal sectors of the same High. High winds and low humidities usually dictated the selection of this type when the other criteria were met. Although it is relatively short-lived, the Chinook can cause extreme and rapid changes in fire weather.

In the Southern Plains region, no distinction was made between Chinooks with air masses originating in the Pacific and those with air masses originating in northwest Canada. In the Northwest Plains region the two were separated. The primary difference was that the frequency of occurrence of Pacific type outweighed the Canadian type by better than 4 to 1.

Tropical storm type.--Tropical storm types occurred only in coastal bordering regions. They were different from all other fire-weather types in that cyclonic rather than anticyclonic circulation was involved. High fire danger was found in the areas with high winds beyond the rain shield. Tropical storms were so few in number that statistics on them were computed only for individual stations. Quadrant structure was the same as for the high pressure systems except that the names given them were North, East, South, and West quadrants. When the storms developed extra-tropical characteristics, they were no longer considered a fire-weather type.

Regions West of the Rockies

The mountainous terrain of the western third of the United States complicated the selection of weather patterns in the six regions west of the Rockies. There is some similarity between western patterns, but the California regions were the only two we felt we could group together. Each pattern is discussed by the region to which it applies.

Northern Rockies and Northern Intermountain Region

Pacific High type.--This type is quite similar to its eastern counterpart except that only two of its four quadrants are important in fire weather in this region. These quadrants were the post-frontal and pre-frontal (fig. 2). This type had the additional requirement of a supporting upper-air flow in the form of a ridge over the western United States and Canada.

Post-frontal: Critical fire weather was found in this quadrant in the area east of the Cascades when frontal passages were dry. High winds and some upper-air support were also required.

Pre-frontal: The pre-frontal quadrant of the surface High in this type bordered the eastern side of a surface thermal trough which extended northward into the region. Under the western side of a slow-moving or stagnant ridge aloft, strong upper-air flow (from the south or southwest) supplemented the surface flow in the thermal trough and pre-frontal areas.

Northwest Canadian High type.--The Northwest Canadian High type has the same quadrant nomenclature as the Pacific High type and only the post-frontal and pre-frontal areas are considered. The principal difference between the two types was the steepness of the ridge aloft, with meridional flow oriented in a manner to permit the entry of a Canadian high pressure area from western Canada.

Other characteristics are the same as the Pacific High type--dry frontal passages, strong winds with upper-air support, and the presence of a thermal trough to the west of the High.

Central Intermountain Region

Meridional Ridge-Southwest flow pattern.--Principally an upper-air phenomenon, this pattern occurs when a ridge builds or moves over the area and a trough is off the coastal United States. The stations under the west side of the ridge, between the ridge and trough lines, were influenced by this pattern. Usually winds near 20 knots or greater

from the southwest and no evidence of significant precipitation or cloudiness were necessary requirements for high fire danger. The surface pattern was not well defined and could be described as troughy with east-west oriented frontal systems to the north.

Pacific High-Meridional Flow.--This and the following types are definite combinations of surface and upper-air patterns. At the surface are definite frontal passages, with an upper-air ridge steering the Pacific High bubble cells from the northwest to the southeast. The upper-air pattern is, of course, meridional with the stations under the eastern side of the ridge.

Pacific High-Zonal Flow.--The Pacific High Zonal Flow type is also a combination of surface and upper-air flow. Unlike the meridional case the zonal pattern is characterized by rapidly-moving, small amplitude waves aloft, quite often downwind of a blocking pattern over the eastern Pacific. It is accompanied at the surface by dry frontal passages followed by rapidly-moving Pacific High cells.

Southwest Region

Meridional Ridge-Southwest Flow pattern.--Similar to the Central Intermountain Region pattern of the same name, this pattern for the Southwest is characterized by a steep long-wave meridional ridge over the eastern or central United States and a well defined Pacific High aloft over the Pacific. High fire danger occurs in the Southwest Region for long periods under the influence of this pattern. It peaks as short-wave troughs pass by and continues until the long-wave pattern moves eastward so that the area comes under the influence of the long-wave trough.

Short Wave Train.--Principally an upper-air pattern similar to the Meridional Ridge, this pattern has upper-air ridges over the eastern Pacific and central United States. But the wave length is smaller and the amplitude is less than in the meridional pattern. Also the surface east Pacific High is very well developed and a low pressure center exists in the Gulf of Alaska. The main belt of westerlies carries short waves through the long-wave pattern. Sometimes a secondary belt of westerlies to the south carries short-wave troughs through the long-wave pattern. The secondary belt of westerlies accompanied by a train of short waves may or may not be accompanied with surface frontal systems.

Zonal Ridge.--Another upper-air pattern, the zonal ridge, is characterized like other Southwest Region patterns, with a ridge to the east and a trough to the west. Quite often a closed contour at 500 mb is located over northern Mexico or the Texas Gulf Coast. The western United States is influenced at the surface by a broad trough, primarily thermal in nature, and high pressure is located over the southeastern states. Pressure gradients are usually weak over the Southwest.

Pacific Northwest

Pacific High with Post-Frontal or East Winds.--High fire danger in the Pacific Northwest region occurs only when the normal maritime climate was intercepted by the occasional invasion of a continental air mass or by subsiding air from aloft over the Pacific anticyclone. During these periods the surface air flow had an offshore component.

The critical fire-weather types are primarily surface types, but the offshore flow is sometimes fortified by a favorable upper-air pattern. In the Pacific High type a "nose" of the surface Pacific High moves into the Pacific Northwest with either meridional or zonal flow aloft and with the ridge situated either off the coast or over the Western United States. Following the passage of a short-wave trough aloft and its associated surface front, the post-frontal quadrant of the High moving in behind the front sets up a pressure gradient favorable for offshore flow. This flow has a continental trajectory and is strongly influenced by subsiding air aloft. When a blocking pattern aloft forms with a closed Low off the California coast, strong easterly winds aloft blow over western Washington and Oregon, amplify the surface flow, and increase fire danger.

Northwest Canadian High with Post-Frontal or East Winds.--Surface winds with an offshore component in the Pacific Northwest region occur much less often with a Northwest Canadian High than with a Pacific High. When they do occur, conditions are similar to those of the Pacific High type.

California Regions

Subtropical High Aloft.--The upper-air flow occurring with a Subtropical High Aloft may be either meridional or zonal. The most important considerations in the classification of this upper-air pattern are the northward displacement of the belt of westerlies and the closed anticyclonic circulation over the southwestern United States. This is usually a stagnant pattern and effectively blocks advection of Gulf of Mexico moisture into California. Periods of abnormally high temperatures (heat waves) and low humidities are associated with this type.

Meridional Ridge-Southwest Flow pattern.--This pattern is quite similar in its structure to those of the Southwest and Central Intermountain Regions. The primary requirement is the location of a ridge to the east and a trough to the west of the area. An important difference between the California Regions and the inland regions is that the Southwest Flow pattern is quite favorable to marine air penetration and low fire danger at coastal and low-level stations. The interior valleys

of California and the stations above the marine layer (which can be very deep at times) are affected adversely. Fire danger peaks with the passage, usually to the north, of short-wave troughs and associated dry frontal systems which increase the pressure gradients.

Pacific High Post-Frontal type.--This is predominantly a surface type in which Pacific air moves in behind a surface cold front and causes north to northeast winds in northern and central California. Usually the upper-air pattern consists of a long-wave ridge over the eastern Pacific and a trough in the Western United States. This is a favorable pattern for steering frontal systems through Oregon and Washington southeastward into Nevada. The trailing ends of cold fronts sweep across the regions, with Pacific air moving in behind them. A foehn effect is produced by steep pressure gradients behind the front causing strong winds to blow from higher elevations down the mountain slopes toward the Coast.

Great Basin High type.--This type often follows the Pacific High Post Frontal type, although similar conditions do exist with the Northwest Canadian air masses. Following a frontal passage, Pacific or Canadian air moves into the Great Basin or intermountain region and stagnates (fig. 3). When a surface thermal trough along the California coast, and the Great Basin High occurs together, a strong pressure gradient creates easterly or northeasterly winds across the Sierra Nevada and the Coast Ranges. The upper-air pattern is usually meridional with a ridge off the West Coast and a trough over the Great Basin. Momentum is transferred from the upper-air northerly flow to the surface flow over the Sierra Nevada and leads ultimately to the Santa Ana type of Southern California.

PROCESSING THE DATA

Preparation of the statistics by synoptic weather type required the grouping and processing of available weather data on magnetic tape. The great mass of data handling and computation immediately pointed to the use of a large-scale computer to perform the task.

The subjectively determined dates of occurrence of synoptic fire-weather types at each station were recorded on hand-written forms. Typically, each occurrence was listed as a string of dates, set off by horizontal lines representing the end of the occurrence, and appeared in an appropriate column headed by the generic name of the weather type and numbered for rapid keypunching.

These data were converted into individual punched cards containing the year, month, type number, and first and last dates of occurrence. Although the use of a single card for each occurrence resulted in a vast number of cards--about 270,000 for the entire study--this method per-

mitted easy keypunching and handling.

The cards were then processed on an IBM 1620 Model II computer; the program checked each card's data for legitimacy of dates, year, etc. and punched out a corresponding card containing a serial record number, range number, type number, month, and other identification. The serial record number represented the tape-record number corresponding to the first date of occurrence, while the range gave the number of records to be read. These cards were then sorted by month and arranged with control cards to give a deck for each station. This deck consisted of a group of 10 (or 12) data-sets, one for each month. Each control card heading contained the station number, number of the synoptic category, and month number, plus other control information for the IBM 7094 computer program.

In the Eastern United States, most stations had 20 synoptic categories; the sheer volume of data precluded processing of all 20 in one pass through the computer. Therefore, the data were separated into two groups, which were processed sequentially.

The IBM 7094 computer program for processing these data consisted of a main program and 19 subroutines. A great deal of flexibility had to be built into the program to provide for wide variation in number and naming of synoptic categories from one station to another.

Essentially the basic unit of computation for this program consisted of a month's (or season's) worth of occurrence data for a specific station. The program read weather data from a tape, according to the occurrence dates, stored the data in a large array, and performed statistical computations on this array. The computer printed out the results as blocked tables by weather types. Since about 36,000 items of weather data had to be accessible for computation, the data were stored in packed form and recalled when needed. In this way, the entire computation was performed at essentially core-speed, although about 20 microseconds were needed to recover the items of packed data from the packed array.

This basic procedure was repeated for each month's data for each station. About 1 minute of computer time was needed to process the data for one station.

Because of the large quantity of cards involved for each station, the operation of off-line card-to-tape conversion was avoided by using a 1013 Card Transmission terminal at the University of California, Riverside. The program and occurrence-data cards were sent by telephone line to the Western Data Processing Center in Los Angeles, where the transmitted data were directly written on tape for on-line processing.

Results

The results of this study consist primarily of the statistics themselves. Consequently most of this report is in tabular form. A summary of the frequency and duration of each of the major synoptic types is recorded in tables 1 through 21. Statistics on weather parameters and fire danger indexes for each type by individual station are reported in 13 separate supplements by region. Examples of these statistics appear in fig. 4.

FREQUENCY AND DURATION OF TYPES

Tables 1 through 4 apply to all eight regions east of the Rockies. Each of the succeeding tables, 5 through 21, apply to individual regions since the similarity among western regions is not so pronounced as among eastern regions. The summarized data in the first four tables have a broader interpretation than those in tables 5-21 because the definition of the duration of a "case" in the East differs somewhat from that for the West. For data summarized in tables 1-4, a case was considered as beginning on the date of origin of the type. For the Pacific High types this origin date was the day when the Pacific High first crossed the continental boundary. For the Canadian and Hudson Bay High types the date of origin was the day the High first moved toward the United States. For the Bermuda High type the day of origin was the first day one or more stations was affected by the Bermuda High. In all four types, the last day on which the type affected the United States was used as the termination date.

Table 1.--Pacific High, regions east of the Rockies, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	60	3	13	5.5	2.2
February	57	3	14	5.8	2.7
March	65	3	13	5.4	2.1
April	50	3	15	6.3	3.0
May	59	3	20	6.6	3.2
June	62	3	13	6.1	2.4
July	55	3	16	6.2	2.6
August	60	3	17	6.2	2.5
September	56	3	13	6.1	2.2
October	68	3	15	6.7	2.7
November	54	3	11	6.0	2.1
December	71	3	13	5.6	2.1
Total	717				

Table 2.--Northwest Canadian High, regions east of the Rockies, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	76	1	17	6.6	2.9
February	64	1	16	6.5	3.1
March	53	1	16	7.1	2.9
April	49	1	15	6.8	3.1
May	38	4	14	7.6	2.7
June	33	2	16	7.2	3.1
July	39	3	10	6.8	2.0
August	48	2	16	7.4	2.8
September	43	3	18	7.0	3.2
October	50	2	18	7.4	3.0
November	63	1	18	6.4	3.1
December	64	2	16	7.1	3.0
Total	620				

Table 3.--Hudson Bay High, regions east of the Rockies, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	9	4	10	7.0	2.0
February	9	1	10	5.3	2.7
March	18	2	12	6.5	2.4
April	16	3	12	6.0	2.4
May	18	1	11	7.0	2.6
June	14	2	10	6.4	2.4
July	8	4	10	7.0	1.8
August	12	3	9	6.1	1.7
September	11	4	12	6.7	2.3
October	12	2	8	4.0	1.7
November	8	3	8	4.8	1.5
December	6	3	9	6.0	1.8
Total	141				

Table 4.--Bermuda High, regions east of the Rockies, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	19	1	19	3.3	4.0
February	16	1	13	4.3	2.9
March	18	1	12	5.0	3.2
April	24	1	25	7.5	6.1
May	18	1	18	8.1	4.9
June	25	1	32	10.9	8.7
July	24	4	35	12.3	8.0
August	27	1	22	8.5	5.0
September	24	2	14	6.2	3.7
October	22	1	12	3.4	2.5
November	19	1	5	2.3	1.3
December	17	1	8	3.4	2.5
Total	253				

Table 5.--Chinook (Pacific and Canadian Highs), Southern Plains, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	11	1	2	1.4	0.4
February	16	1	2	1.4	0.4
March	31	1	3	1.3	0.6
April	18	1	4	1.2	0.7
May	11	1	2	1.1	0.3
June	5	1	4	1.8	1.1
July	2	1	1	1.0	0.0
August	1	-	-	1.0	---
September	8	1	1	1.0	0.0
October	5	1	2	1.2	0.4
November	16	1	3	1.3	0.5
December	15	1	4	1.3	0.7
Total	139				

Table 6.--Chinook (Pacific High), Northwest Plains, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	20	1	3	1.2	0.5
February	17	1	3	1.1	0.5
March	20	1	2	1.2	0.4
April	9	1	3	1.5	0.6
May	11	1	2	1.2	0.4
June	10	1	2	1.2	0.4
July	9	1	3	1.6	0.6
August	10	1	2	1.1	0.3
September	22	1	3	1.2	0.5
October	16	1	5	1.6	1.2
November	17	1	3	1.4	0.6
December	20	1	2	1.0	0.2
Total	181				

Table 7.--Chinook (Northwest Canadian High), Northwest Plains, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	1	-	-	1.0	---
February	2	1	1	1.0	0.0
March	1	-	-	2.0	---
April	0	-	-	---	---
May	3	1	1	1.0	0.0
June	2	1	1	1.0	0.0
July	1	-	-	1.0	---
August	3	1	1	1.0	0.0
September	4	1	2	1.2	0.4
October	13	1	3	1.2	0.5
November	9	1	2	1.1	0.3
December	4	1	1	1.0	0.0
Total	43				

Table 8.--Pacific High, Northern Rockies and Northern Intermountain Region, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	21	1	6	1.8	1.2
February	20	1	3	1.6	0.8
March	34	1	4	1.4	0.8
April	30	1	6	2.0	1.2
May	36	1	8	1.9	1.4
June	41	1	6	2.1	1.2
July	52	1	9	3.2	2.0
August	52	1	8	3.2	1.8
September	42	1	7	2.5	1.7
October	30	1	8	1.9	1.6
November	20	1	6	1.9	1.3
December	19	1	5	1.6	1.0
Total	397				

Table 9.--Northwest Canadian High, Northern Rockies and Northern Intermountain Region, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	4	1	4	2.0	1.2
February	3	1	2	1.6	0.4
March	8	1	2	1.2	0.4
April	9	1	2	1.3	0.4
May	7	1	2	1.2	0.4
June	13	1	4	2.0	0.8
July	12	1	7	2.5	1.7
August	9	1	7	2.4	1.6
September	14	1	7	2.6	1.9
October	9	1	3	2.2	0.6
November	7	1	7	3.1	1.9
December	2	1	2	1.5	0.5
Total	97				

Table 10.--Meridional Ridge (Southwest Flow), Central Intermountain Region, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	29	1	11	2.5	2.0
February	27	1	10	2.2	1.8
March	34	1	6	2.2	1.0
April	32	1	7	2.9	1.6
May	37	1	15	4.3	2.9
June	37	1	23	6.1	4.7
July	34	1	22	6.2	5.8
August	27	1	26	6.6	5.9
September	32	1	16	4.1	3.9
October	33	1	7	2.7	1.5
November	26	1	7	2.6	1.5
December	28	1	13	2.0	2.2
Total	376				

Table 11.--Pacific High (Post-Frontal Meridional) Central Intermountain Region, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	2	1	2	1.5	0.5
February	5	1	18	4.6	6.7
March	9	1	2	1.3	0.4
April	9	1	2	1.5	0.4
May	12	1	3	1.5	0.7
June	11	1	2	1.4	0.4
July	7	1	2	1.5	0.4
August	9	1	5	2.1	1.0
September	13	1	2	1.3	0.4
October	13	1	3	1.4	0.6
November	6	1	1	1.0	0.0
December	7	1	3	1.5	0.7
Total	103				

Table 12.--Pacific High (Post-Frontal Zonal), Central Intermountain Region, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	4	1	2	1.2	0.4
February	2	1	1	1.0	0.0
March	4	1	1	1.0	0.0
April	12	1	3	1.4	0.6
May	7	1	3	1.7	0.8
June	22	1	4	1.8	0.9
July	12	1	3	1.4	0.6
August	13	1	5	2.0	1.0
September	18	1	2	1.2	0.4
October	11	1	2	1.4	0.4
November	4	1	1	1.0	0.0
December	4	1	1	1.0	0.0
Total	113				

Table 13.--Meridional Ridge (Southwest flow), Southwest Region, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	12	1	9	2.5	2.2
February	4	1	3	1.7	0.8
March	12	1	3	1.9	0.7
April	18	1	5	2.6	1.2
May	29	1	11	3.2	2.0
June	20	1	17	4.7	4.1
July	15	1	8	2.1	1.7
August	9	1	4	2.0	1.0
September	15	1	7	2.5	1.5
October	11	1	4	2.3	1.0
November	13	1	3	1.7	0.5
December	5	1	6	3.2	1.7
Total	163				

Table 14.--Short wave train, Southwest Region, 1951-1960

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	11	1	5	2.4	1.3
February	9	1	11	3.2	2.9
March	17	1	7	2.0	1.4
April	23	1	16	3.7	4.4
May	16	1	5	2.6	1.2
June	7	1	6	2.8	1.7
July	0	-	--	---	---
August	1	-	--	4.0	---
September	7	1	7	3.2	2.4
October	12	1	3	2.0	0.7
November	8	1	5	2.2	1.2
December	10	1	4	1.9	1.1
Total	121				

Table 15.--Zonal ridge, Southwest Region, 1951-1960

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	22	1	8	2.2	1.8
February	19	1	4	2.0	0.9
March	23	1	8	1.9	1.5
April	18	1	7	3.0	1.8
May	17	1	5	2.2	1.0
June	14	1	11	3.2	2.6
July	10	1	4	1.9	1.1
August	9	1	8	3.7	2.6
September	11	1	14	4.2	3.7
October	9	1	7	2.5	1.7
November	14	1	5	2.5	1.2
December	18	1	4	1.8	0.9
Total	184				

Table 16.--Pacific High (Offshore flow), Pacific Northwest Region, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	6	1	2	1.8	0.3
February	9	1	8	2.4	2.2
March	12	1	4	1.9	1.0
April	13	1	5	2.0	1.1
May	18	1	5	2.1	1.2
June	23	1	6	2.1	1.2
July	34	1	7	3.0	1.4
August	31	1	7	2.3	1.4
September	30	1	5	2.5	1.2
October	23	1	6	2.3	1.5
November	6	1	8	3.3	2.4
December	6	1	6	2.5	1.7
Total	211				

Table 17.--Northwest Canadian High (Offshore flow), Pacific Northwest Region, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	7	1	7	3.2	1.9
February	7	1	5	2.2	1.3
March	1	-	-	2.0	---
April	5	1	3	2.2	0.7
May	1	-	-	2.0	---
June	0	-	-	---	---
July	0	-	-	---	---
August	0	-	-	---	---
September	9	1	5	3.1	1.1
October	2	3	5	4.0	1.0
November	6	1	4	2.3	1.1
December	3	1	5	3.0	1.6
Total	41				

Table 18.--Subtropical High Aloft, California Regions, 1951-1960

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	0	-	-	---	---
February	0	-	-	---	---
March	0	-	-	---	---
April	0	-	-	---	---
May	0	-	-	---	---
June	13	1	6	3.7	1.4
July	20	1	26	8.8	7.7
August	24	1	22	4.6	4.5
September	14	1	12	4.7	2.9
October	4	2	4	2.7	0.8
November	0	-	-	---	---
December	0	-	-	---	---
Total	75				

Table 19.--Meridional Ridge (Southwest flow), California Regions 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	4	1	6	3.5	1.8
February	6	1	4	2.5	1.2
March	7	1	3	2.0	0.7
April	13	1	3	1.6	0.7
May	17	1	13	3.0	2.9
June	20	1	15	3.6	3.1
July	25	1	13	3.4	2.6
August	29	1	8	4.0	1.9
September	22	1	12	3.2	2.7
October	18	1	10	2.0	2.0
November	12	1	8	2.5	1.7
December	6	1	3	1.8	0.6
Total	179				

Table 20.--Pacific High (Post-Frontal), California Regions, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	26	1	5	1.3	0.8
February	24	1	2	1.2	0.4
March	31	1	3	1.2	0.5
April	34	1	3	1.3	0.5
May	22	1	2	1.2	0.4
June	34	1	3	1.2	0.5
July	13	1	3	1.5	0.6
August	16	1	2	1.5	0.5
September	28	1	3	1.4	0.5
October	32	1	3	1.3	0.5
November	28	1	2	1.4	0.4
December	26	1	2	1.2	0.4
Total	314				

Table 21.--Great Basin High, California Regions, 1951-1960.

Month	Number of Cases	Range-Days Minimum	Range-Days Maximum	Mean Duration	Standard Deviation
January	38	1	10	2.8	1.9
February	28	1	6	2.4	1.2
March	26	1	6	2.6	1.4
April	24	1	5	2.2	1.0
May	18	1	5	2.2	1.1
June	21	1	4	1.5	0.8
July	12	1	4	2.0	1.0
August	13	1	4	1.9	0.9
September	33	1	5	2.3	1.0
October	37	1	7	2.8	1.4
November	36	1	14	3.6	2.6
December	35	1	8	3.1	1.9
Total	321				

For the types described in tables 5-21 the duration of a case was defined as the inclusive dates in which the type affected at least one station within the region concerned. The difference in definition of the duration of a case is reflected in the statistics in tables 1-4. The range becomes a little broader and the mean and standard deviation a little larger.

Considerable differences between stations exist for nearly all types reported. These differences are not apparent in the 21 summary tables because only regions or, in the East, groups of regions are considered. For differences between stations the detailed information in the individual supplements will be helpful.

Types East of the Rockies

The most frequently observed type in the United States, the Pacific High type (table 1), averaged nearly six cases per month at one or more eastern stations. April was the month with the least number of occurrences and December the greatest number. There were no great seasonal differences in the number of cases occurring, but the mean duration was somewhat less in the winter than the other seasons, reflecting the stronger wintertime general circulation.

Since it took more than 2 days for a Pacific High to affect the eastern regions, cases of 1 and 2 days duration were eliminated. This accounts for the 3-day minimum.

The Northwest Canadian High type (table 2) was the second most frequently observed type. It averaged 5.2 cases per month. The somewhat more variable monthly occurrence was reflected in the summer minimum and winter maximum. This seasonal difference was not extended to the mean duration where there was a good deal more uniformity. An interesting point worth noting is that no 1-day occurrences existed during the summer and fall months from May through October. This absence confirms the existence of slower moving or stagnating systems which cause the higher fire danger during the summer season. In the winter months, when the westerlies are over the Northern United States, air masses move through the area much more rapidly and account for the occasional 1-day occurrences.

The Hudson Bay High type showed a distinct seasonal variation in occurrence (table 3). Not only was this type more likely to occur in the spring and fall, but those cases occurring in the spring lasted longer by 3 to 4 days in some cases.

Some significant characteristics of the Bermuda High type are apparent in table 4. This type occurred more often in the spring, summer, and fall than in the winter. Not only did the frequency peak in the late summer as might be expected, but maximum and mean duration were much higher in June and July. In mid-summer a Bermuda High averaged nearly 2 weeks in duration and could last more than a month. From a fire-weather standpoint June and July can become quite severe in the East and remain that way for weeks.

The Chinook type is normally thought of as being a winter and spring phenomenon. And in the Southern Plains (table 5) this is the case, although some do occur in the summer months. The Northwest Plains indicated a winter and fall maximum (tables 6 and 7), but there were a surprising number in the other months, especially of the Pacific High type. It is worth noting that relatively high fire danger occurs on these days in the summer months, while much lower fire danger occurs in winter (see station statistics for Lander, Wyoming in Supplement No. 8). Since the Chinook is by definition a warm sector phenomenon, the high winds caused by tight gradients and the low humidities caused by the foehn effect accounted for the critical fire weather and were much more significant in the summer than in the winter.

Types West of the Rockies

As was mentioned earlier, types in the West were handled somewhat differently from those in the East. Because of regional differences the types were treated separately by regions. This accounts for the large number of types in the West and their shorter duration. The short duration Chinooks in the East and the long duration Meridional Ridge-Southwest Flow types (table 10) in the West are exceptions.

The surface types (Pacific and Canadian air masses), as they were defined for the western regions, had their peak occurrence in the summer (tables 8, 9, 12, 16) for all western regions. There were three exceptions, (tables 11, 20) Pacific Highs showed two peaks,--one in spring and one in fall and Northwest Canadian High showed a summer minimum (table 17). This, of course, should be expected for the Pacific Northwest. The range and mean duration were somewhat variable for Pacific and Canadian High types but all of them tended to peak in late summer and fall. The Great Basin High type (table 21), which is responsible for the Mono and Santa Ana winds of California, peaked in fall and winter in its frequency of occurrence and in the fall for its duration. Since this type can be a cause of extreme fire weather lasting for as much as a week or more, it should be noted that it occurred quite often in all months, although its duration was shorter in the summer than in the fall and winter.

The upper-air patterns (tables 10, 13, 14, 15, 18, 19) also have some unique features in common. All tended to occur most often in the spring and summer. Their mean duration also peaked in the late spring and summer, except the Zonal Ridge pattern (table 15), which had a definite peak in September.

A major feature of the Meridional Ridge-Southwest Flow pattern (table 10) and the Subtropical High Aloft (table 18) is their relatively long duration. Some lasted nearly a month, usually in the summer, and were responsible for long periods of critical fire weather.

STATION STATISTICS

The entire 10 years of statistical data are grouped by station, month, and type. Figure 4 is an example of statistical data for St. Louis, Missouri. It illustrates the arrangement of the four quadrants of the Pacific and Northwest Canadian High types, the weather parameters and fire danger indexes evaluated and their statistical values. For example, there were 86 days of Pacific High type at St. Louis. The post-frontal quadrant had 25 of these days, the south quadrant 17, and so on.

On the post-frontal days the dewpoint ranged in value from 35 to 69. The first quartile indicates that on 75 percent of the days the dewpoint was greater than or equal to 47° F. The second quartile indicates that on 50 percent of the days the dewpoint was greater than or equal to 55° F, and so on. The mean and standard deviation are given as another measure of the central tendency and variation. The other weather parameters and fire danger indexes should be interpreted in the same manner as the dewpoint.

In parentheses at the bottom of the table for each quadrant are the number of days on which 0.2 inches or more of precipitation occurred and the number of days on which a measurable amount of precipitation occurred. A measurable amount of precipitation is 0.005 inch or more. For the post-frontal days illustrated, 8 of them had a measurable amount of precipitation and 4 of those 8 had 0.2 of an inch or more.

The precipitation data are based on the 24-hour measurement ending the previous midnight. The maximum humidity statistics were determined from the maximum humidity for the day in question. Usually this would have occurred in the early morning. All of the other statistics except average wind speed are for an early afternoon observation. Usually this was 1400 local standard time, although for a few stations 1300 or 1500 was selected so that all of the observations in a region would be for the same actual time. The average wind speed is based on the speed at the observation time and at the two previous hourly observations.

All data for all types are presented in the supplements in exactly the same way as illustrated in figure 4.

STATION NO. 13994 ST. LOUIS (WBAS), MISSOURI SEPTEMBER 1951 - 1960

PACIFIC HIGH, POST FRONTAL

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	25	35	69	47.5	55.0	62.2	54.2	9.4
DRYBULB TEMPERATURE	25	65	100	71.0	75.0	85.7	78.5	9.7
RELATIVE HUMIDITY	25	11	90	33.7	46.0	53.5	47.3	18.8
CLOUD AMOUNT	25	0	10	0.	7.0	10.0	5.2	4.4
AVERAGE WIND SPEED	[illegible]	[illegible]	[illegible]	[illegible]	10.0	12.0	10.5	4.5
PREV. MAX. HUMIDITY	25	45	100	74.0	91.0	93.2	[illegible]	14.1
TIMBER BURNING INDEX	25	0	54	2.0	4.0	9.0	8.2	11.1
FIRE IGNITION INDEX	25	0	95	10.2	39.0	49.7	34.8	25.2
FIRE LOAD INDEX	25	0	84	0.7	2.0	6.0	7.9	16.7
PRECIPITATION	25	(NO. OF DAYS WITH .2 IN. OR MORE = 4)						
		(NO. OF DAYS WITH MEAS. AMOUNT = 4)						

PACIFIC HIGH, SOUTH QUADRANT

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	17	41	64	45.0	49.0	55.0	49.9	5.9
DRYBULB TEMPERATURE	17	70	83	73.7	79.0	80.2	77.2	4.2
RELATIVE HUMIDITY	17	26	55	33.7	38.0	43.7	39.5	8.5
CLOUD AMOUNT	17	0	8	0.	0.	1.2	1.6	2.9
AVERAGE WIND SPEED	17	[illegible]	[illegible]	[illegible]	[illegible]	10.0	[illegible]	2.8
PREV. MAX. HUMIDITY	17	61	96	83.7	89.0	90.0	85.5	7.9
TIMBER BURNING INDEX	17	3	16	4.7	5.0	7.0	6.0	2.8
FIRE IGNITION INDEX	17	21	62	40.5	50.0	52.0	45.5	11.2
FIRE LOAD INDEX	17	1	14	2.7	5.0	6.0	5.0	2.9
PRECIPITATION	17	(NO. OF DAYS WITH .2 IN. OR MORE = 0)						
		(NO. OF DAYS WITH MEAS. AMOUNT = 2)						

PACIFIC HIGH, NORTH QUADRANT

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	8	40	62	44.0	47.0	51.5	49.4	6.5
DRYBULB TEMPERATURE	8	66	89	69.0	75.0	80.5	75.5	7.3
RELATIVE HUMIDITY	8	20	58	34.0	43.5	46.0	40.4	11.1
CLOUD AMOUNT	8	0	9	1.0	4.0	8.5	4.5	3.6
AVERAGE WIND SPEED	8	5	13	6.5	7.0	8.5	7.7	2.3
PREV. MAX. HUMIDITY	8	73	100	81.0	91.0	98.5	88.9	10.1
TIMBER BURNING INDEX	8	2	16	3.5	3.0	6.0	5.1	4.4
FIRE IGNITION INDEX	8	22	82	36.5	39.5	55.0	46.2	17.1
FIRE LOAD INDEX	8	1	23	2.0	2.0	6.0	5.5	6.9
PRECIPITATION	8	(NO. OF DAYS WITH .2 IN. OR MORE = 0)						
		(NO. OF DAYS WITH MEAS. AMOUNT = 1)						

PACIFIC HIGH, PRE-FRONTAL

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	34	38	71	47.0	52.5	64.0	54.1	9.3
DRYBULB TEMPERATURE	34	70	91	79.0	83.0	87.0	82.6	5.3
RELATIVE HUMIDITY	34	17	78	30.0	36.5	46.0	39.1	11.9
CLOUD AMOUNT	34	0	10	0.	3.0	8.0	3.8	3.7
AVERAGE WIND SPEED	34	4	18	8.0	11.0	13.0	10.8	3.2
PREV. MAX. HUMIDITY	34	60	100	77.0	85.0	90.0	83.6	9.5
TIMBER BURNING INDEX	34	0	18	6.0	7.0	11.0	[illegible]	3.7
FIRE IGNITION INDEX	34	0	83	41.0	50.0	52.0	46.4	14.5
FIRE LOAD INDEX	34	0	23	5.0	6.0	8.0	6.8	4.3
PRECIPITATION	34	(NO. OF DAYS WITH .2 IN. OR MORE = 0)						
		(NO. OF DAYS WITH MEAS. AMOUNT = 7)						

NORTHWEST CANADIAN HIGH, POST-FRONTAL

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	24	35	69	49.5	59.5	63.0	56.4	8.7
DRYBULB TEMPERATURE	24	50	94	71.0	75.5	86.5	77.1	10.5
RELATIVE HUMIDITY	24	28	97	33.3	58.0	74.5	53.1	20.9
CLOUD AMOUNT	24	0	10	1.5	5.5	10.0	5.7	4.1
AVERAGE WIND SPEED	24	3	18	8.5	10.0	13.0	10.4	3.4
PREV. MAX. HUMIDITY	24	53	100	78.5	91.0	97.5	[illegible]	14.6
TIMBER BURNING INDEX	24	0	17	1.0	5.0	7.5	5.4	5.1
FIRE IGNITION INDEX	24	0	55	1.0	29.0	52.0	27.5	23.3
FIRE LOAD INDEX	24	0	15	0.	2.5	6.0	3.9	4.5
PRECIPITATION	24	(NO. OF DAYS WITH .2 IN. OR MORE = 4)						
		(NO. OF DAYS WITH MEAS. AMOUNT = 9)						

NORTHWEST CANADIAN HIGH, SOUTH QUADRANT

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	40	27	67	41.0	45.5	52.5	46.3	8.2
DRYBULB TEMPERATURE	40	57	94	67.5	70.5	74.5	71.7	7.3
RELATIVE HUMIDITY	40	23	85	31.0	39.0	50.0	42.9	16.0
CLOUD AMOUNT	40	0	10	0.	1.0	9.0	3.3	4.2
AVERAGE WIND SPEED	40	4	18	7.5	10.0	12.0	10.0	3.3
PREV. MAX. HUMIDITY	40	72	100	78.0	85.5	91.5	85.2	8.0
TIMBER BURNING INDEX	40	0	29	3.0	5.5	7.5	6.0	4.4
FIRE IGNITION INDEX	40	[illegible]	73	23.5	39.5	49.0	36.9	20.1
FIRE LOAD INDEX	40	0	26	1.5	5.0	6.0	4.9	5.0
PRECIPITATION	40	(NO. OF DAYS WITH .2 IN. OR MORE = 4)						
		(NO. OF DAYS WITH MEAS. AMOUNT = 9)						

NORTHWEST CANADIAN HIGH, NORTH QUADRANT

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	2	44	50				47.0	
DRYBULB TEMPERATURE	2	79	86				82.5	
RELATIVE HUMIDITY	2	29	29				29.0	
CLOUD AMOUNT	2	0	7				3.5	
AVERAGE WIND SPEED	2	10	13				11.5	
PREV. MAX. HUMIDITY	2	82	95				88.5	
TIMBER BURNING INDEX	2	3	15				9.0	
FIRE IGNITION INDEX	2	22	53				37.5	
FIRE LOAD INDEX	2	1	14				7.5	
PRECIPITATION	2	(NO. OF DAYS WITH .2 IN. OR MORE = 1)						
		(NO. OF DAYS WITH MEAS. AMOUNT = 1)						

NORTHWEST CANADIAN HIGH, PRE-FRONTAL

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	50	33	68	45.0	51.5	60.0	52.2	6.5
DRYBULB TEMPERATURE	50	71	98	79.0	85.0	91.0	85.2	7.3
RELATIVE HUMIDITY	50	19	70	27.0	32.0	38.0	33.7	10.5
CLOUD AMOUNT	50	0	10	0.	1.0	5.0	2.8	3.4
AVERAGE WIND SPEED	50	5	18	9.0	10.0	13.0	10.8	3.3
PREV. MAX. HUMIDITY	50	50	97	70.0	80.0	86.0	77.0	11.7
TIMBER BURNING INDEX	50	1	24	7.0	9.0	15.0	11.3	5.9
FIRE IGNITION INDEX	50	2	83	49.0	52.5	60.0	54.0	14.6
FIRE LOAD INDEX	50	0	29	6.0	7.0	14.0	10.6	7.5
PRECIPITATION	50	(NO. OF DAYS WITH .2 IN. OR MORE = 0)						
		(NO. OF DAYS WITH MEAS. AMOUNT = [illegible])						

HUDSON BAY HIGH, POST FRONTAL

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	5	40	59	43.0	49.0	56.0	47.2	7.0
DRYBULB TEMPERATURE	5	62	94	69.0	72.0	86.5	76.4	11.3
RELATIVE HUMIDITY	5	21	79	23.2	41.0	70.7	44.6	24.1
CLOUD AMOUNT	5	0	10	1.5	9.0	10.0	6.2	4.3
AVERAGE WIND SPEED	5	5	18	6.5	10.0	14.2	10.6	4.6
PREV. MAX. HUMIDITY	5	62	95	75.5	94.0	[illegible]	77.4	7.5
TIMBER BURNING INDEX	5	1	17	1.7	9.0	17.0	3.0	7.0
FIRE IGNITION INDEX	5	0	73	9.0	49.0	64.7	39.2	28.4
FIRE LOAD INDEX	5	0	20	0.7	5.0	17.7	8.6	8.3
PRECIPITATION	5	(NO. OF DAYS WITH .2 IN. OR MORE = 0)						
		(NO. OF DAYS WITH MEAS. AMOUNT = [illegible])						

HUDSON BAY HIGH, SOUTH QUADRANT

	NO. OF DAYS	RANGE MIN	RANGE MAX	QUARTILES 1ST	2ND	3RD	MEAN VALUE	STANDARD DEVIATION
DEWPOINT	3	51	61				56.3	
DRYBULB TEMPERATURE	3	72	82				76.0	
RELATIVE HUMIDITY	3	44	49				47.0	
CLOUD AMOUNT	3	0	8				5.0	
AVERAGE WIND SPEED	3	5	10				6.7	
PREV. MAX. HUMIDITY	3	89	94				91.3	
TIMBER BURNING INDEX	3	4	6				4.7	
FIRE IGNITION INDEX	3	33	39				37.0	
FIRE LOAD INDEX	3	2	5				3.0	
PRECIPITATION	3	(NO. OF DAYS WITH .2 IN. OR MORE = 0)						
		(NO. OF DAYS WITH MEAS. AMOUNT = 1)						

Figure 4.--An example of the station statistics as they appear in the supplements.

Applications

The statistical form of the bulk of this report leaves wide latitude for applying the results. We have identified three broad areas in which the results can be readily used. The first two, fire weather forecasting and fire control planning are operational areas; the third area can be of immediate concern to the researcher, that is, a new basis upon which he can improve his understanding of weather and fire phenomena. There is, of course, no clear distinction among these three areas.

FIRE WEATHER FORECASTING

Admittedly there are limitations to how far these data will permit a forecaster to go with probability forecasting. But the fact remains that he now has a basis upon which he can make a quantitative probability forecast for a particular event. For example, in figure 4 there were 25 Pacific Post-Frontal days in September out of a possible 300 September days. Therefore there is about an 8 percent chance that St. Louis will be in the post-frontal area of a Pacific High in September. Also by summing the Pacific High and Canadian High days, we would have about a 29-percent chance of getting a Pacific High and about a 39-percent chance of a Canadian High. On a percentage basis, we can compare between quadrants, types, months, etc. to suit specific needs. There is, of course, a good deal of variability between years, and the forecaster will not be relieved of the necessity of predicting the event based on presently used methods.

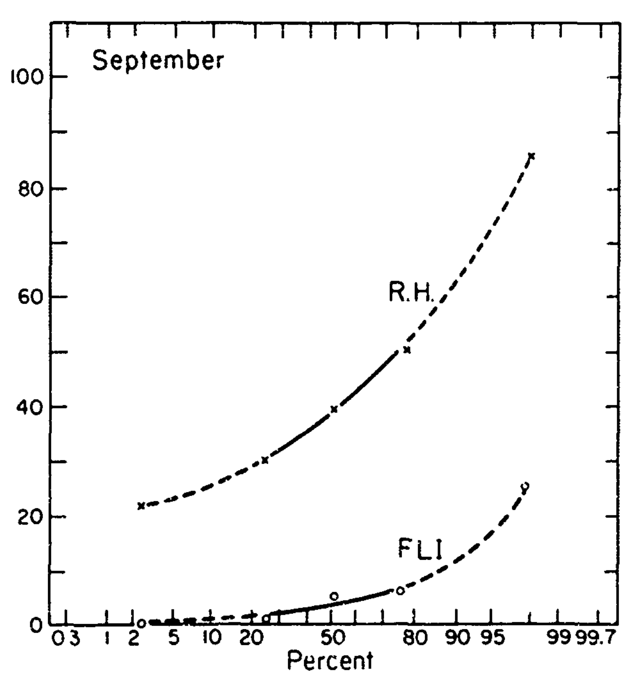

Figure 5.--An example of cumulative percent frequency plots from the quartiles and minimum and maximum values for St. Louis, Northwest Canadian High South Quadrant, shown in figure 4.

These data will, however, give him a quantitative idea of what the odds might be, based on climatology.

Similarly, the weather parameters (dewpoint, temperature, etc.) may be given objectively determined values through use of cumulative frequency curves of the particular parameter. For example, from figure 5, in which a curve of cumulative percent frequency for relative humidity is plotted from range and quartile data in figure 4, it is possible to conclude that on days when St. Louis is in the south quadrant of a Northwest Canadian High, relative humidity of 60 percent or lower may be expected about 85 percent of the days, 25 percent or lower on 9 percent of the days, and so forth. Similar frequency curves can be plotted for other weather parameters and for fire danger indexes. The three quartiles provide three points for the curve. Two end points may be obtained from the maximum and minimum values, but not without making assumptions as to the number of times the minimum and maximum values occurred. For most elements a reasonable assumption is that these values occurred only once. With this assumption and the total number of days, the percentage may be calculated. This assumption would not be reasonable for 0 and 10 tenths for cloud amount, 100 percent for maximum relative humidity, and 0 and 99 for the fire danger indexes.

Forecasters may use the data in other meaningful ways. By comparing the various weather parameters to one another from one quadrant or type to another, they will get a better idea about how these parameters will vary. The forecaster can state with some assurance that one type or quadrant is worse or better than another for some specific purpose. He can also state how months and seasons will alter the parameters, by how much and in which direction. In figure 4, such differences appear between Pacific and Canadian post-frontal cases for temperature, humidity, and fire load index. From a fire-weather standpoint the Pacific post-frontal cases in September in St. Louis are obviously worse than the Canadian because of the higher temperatures and lower humidities, than at other times. Relative humidity appears to be the controlling factor.

FIRE CONTROL PLANNING

If the material presented here helps to improve the art of forecasting fire weather, it will be of benefit to the fire control agencies. In addition to such indirect benefits, there are direct advantages the fire control planner can derive from the data in its present form. For example, he can obtain the probability of occurrence of each fire-weather type for each month from tables 1-21. He can also

make an estimate of the duration of each type.

By examining the fire danger indexes in the supplements, the fire control planner will know which types are more critical than others, when and where they are likely to occur, and how severe they are likely to be. For example, at St. Louis in September, the Northwest Canadian High pre-frontal is more severe than the other types illustrated. Its temperatures are higher and humidities lower, and cloud cover is significantly less. Together these variables influenced the fire danger indexes. Since the quadrant occurred more often (50 days) and has higher danger indexes than any other type it should be most suspect from a fire standpoint. For long-range planning this kind of information can be quite helpful in anticipating peak demands at various locations and in understanding how these demands will change throughout the year.

Chandler and Schroeder[5/] had indicated how fire danger index probabilities can have operational application to the Office of Civil Defense and other agencies active in fire control. The data used were those published in the previous report. The data published in the supplements to this report can be used in a similar manner.

Figure 5 shows a plotted curve of the cumulative percent frequency of fire load index values for St. Louis in September for the south quadrant of the Northwest Canadian High type. This curve was plotted in the same manner as the relative humidity curve which was discussed above. From this curve the probability of the fire load index falling onto selected classes can be obtained. If the same classes that were used by Chandler and Schroeder[5/] for all days of a particular month of the 10-year period are used here for the days on which the station was in the south quadrant of the Northwest Canadian High type, then the probability of effective post-attack fire fighting can be obtained. For example, the probability of fire out (FLI 0) would be about 3 percent. The probability of no spread (FLI 1-4) would be 50 minus 3 or 47 percent. The probability of actionable (FLI 5-21) would be 97 minus 50 or 47 percent. And the probability of critical (FLI 22 or higher) would be 100 minus 97 or 3 percent. Other indexes and other classes could be used in the same way for specific purposes.

[5/] Chandler, Craig C., and Schroeder, Mark J. Probability of effective post-attack fire fighting in wildlands. Office of Civil Defense Research Report 10, 9 pp. March 1965. (Limited dist.)

BASIS FOR FURTHER WORK

A third application of the results of this study is through their use as information upon which to base further research. They could be used as the basis for studies aimed at refining probability fire-weather forecasts for local areas, for example. The statistics presented here could be extended to other stations by developing relationships between these stations and the network stations used in this report.

Obviously there are many other ways in which the data obtained through this study can be applied. We have tried to point out only a few ways in which they may be readily used.

Conclusions

1. The first part of the synoptic fire-weather patterns study considered only cases of high fire danger selected by high fire load index. It left unanswered the question whether or not the fire danger was always high when the fire-weather types occurred. The answer, as expected, is negative. Some of the parameters that affect fire danger are not evident in the pressure pattern. These include precipitation, temperature, and past weather. Therefore the forecaster must consider other factors besides the pressure pattern in making his determination of whether or not a particular situation will produce critical fire weather.

2. If the forecaster gives proper consideration to such factors as antecedent weather, available moisture, cloud cover, surface and fuel conditions, and effects of topography, the statistics developed by this study can aid him in predicting specific values of several weather parameters. In particular these statistics can aid in estimating probabilities of occurrence of values.

3. Fire control personnel should find the statistics from this study useful in the development of long-range plans. From the frequency of occurrence tables they can obtain the probabilities of occurrence of the serious fire-weather types, and from the station statistics they can obtain estimates of the severity of several types.

Recommendations

1. Develop and implement a plan in which daily predictions of fire danger are made for all regions of the United States and are used in determining the susceptibility of regions, or portions thereof, to post-attack fire damage. The information developed in this study should be helpful in making such predictions.

2. Refine the classification of synoptic fire-weather types on a regional basis in an attempt to eliminate, by synoptic-scale evidence if possible, the cases of low fire danger. This refinement could best be carried out within regions where more detailed information on fire danger conditions would be available.

Regional Statistics

The 13 supplements to this report provide statistics on weather parameters and fire danger indexes at each city of the 89-station network. There is a volume for each region described in the previous report,[6] with the exception of California. Northern and southern California were combined into a single supplement because of their similarities and because few stations were involved. The statistics in the 13 volumes are in the same order as in the previous report so as to make reference easier. The region covered by each supplement is as follows:

Supplement No. 1 -- Northeast Region
Supplement No. 2 -- Southeast Region
Supplement No. 3 -- Lake States Region
Supplement No. 4 -- Ohio and Middle Mississippi Valleys Region
Supplement No. 5 -- West Gulf States Region
Supplement No. 6 -- Southern Plains Region
Supplement No. 7 -- Northeast Plains Region
Supplement No. 8 -- Northwest Plains Region
Supplement No. 9 -- Northern Rockies and Northern Intermountain Region
Supplement No. 10-- Central Intermountain Region
Supplement No. 11-- Southwest Region
Supplement No. 12-- Pacific Northwest Region
Supplement No. 13-- California Region

Each volume is printed and bound separately. The supplements can be purchased from the Clearinghouse for Federal Scientific and Technical Information, U. S. Department of Commerce, Springfield, Virginia 22151.

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[6] Schroeder, et al. Op cit.

Summary

Weather is one of the dominant factors responsible for uncontrollable spread of mass fires in both urban and rural areas. Identification of the weather types causing critical burning conditions in 14 contiguous regions of the United States was the subject of the previous report.[2/] But to be of much practical value, knowing what the critical weather types are and where they influence burning conditions adversely is not enough. We must also know when they will occur and the type of weather and burning conditions that can be expected. This study is a step in that direction.

Ten years of synoptic weather maps (1951-1960) were studied to determine the frequency of occurrence of each of 21 critical fire-weather types, by months, on a year-round basis. Next, various statistics were computed showing mean values and variations of weather parameters and fire danger indexes, by type and month, at each of a network of 89 representative cities. Using these data as a climatology reference, fire-weather forecasters should be able to make a first approximation probability statement about the occurrence of a particular weather event.

[2/] Schroeder, Mark J., et al. Synoptic weather types associated with critical fire weather. U. S. Forest Serv., Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif., 492 pp., illus. 1964.

METHODS

Classifying Fire Weather Types

The critical fire-weather types were selected from either the Northern Hemisphere Synoptic Weather Series maps or U. S. Weather Bureau Analysis Center micro-film copies for the period 1951 through 1960. Each type was projected forward in time and space from morning charts to coincide with the early afternoon weather observation for each city selected. Guidelines were set up to maintain continuity in the selection of cases and to provide for such problems as dividing high pressure cells, bubble Highs separating from parent Highs, merging between types, etc.. To account for differences in burning conditions, the Highs were divided into quadrants identified as post-frontal, pre-frontal, or north or south quadrants. General precipitation days were eliminated when possible by noting plotted station data, but since air-mass precipitation cannot always be determined in this way, many days with precipitation and low fire danger were included. These days could have been eliminated easily by machine, but including them gave a truer picture of the probability of high fire danger.

In the East there are four primary surface High types: Pacific, Northwest Canadian, Hudson Bay, and Bermuda Highs. In the West, there are combinations of surface and upper-air types partly because of complicated terrain. These are appropriately named. Most critical fire-weather types are associated with the anticyclonic flow in surface high pressure systems or upper-air ridges. One notable exception is the Chinook type.

Regions East of the Rockies.--There are eight regions east of the Rocky Mountains. Because of their similarities they are discussed as a group for each of the weather types affecting them. The East is affected by six critical fire-weather types. Four of them--Pacific, Northwest Canadian, Hudson Bay, and Bermuda Highs--affect all regions, while the Pacific and Canadian Chinook and Tropical Storm types affect only limited areas.

The Pacific High was by far the most prevalent of the four primary types, followed by the Northwest Canadian, Bermuda, and Hudson Bay High types. Fire danger around the periphery of the High, where pressure gradients are tighter, is higher than elsewhere. Normally as a High passed a station its eastern most quadrant (post-frontal) was followed by the south or north quadrant and then the pre-frontal quadrant. For a station to remain in each quadrant 1 or 2 days was not unusual, but, with fast moving systems, a quadrant might occasionally skip a station altogether.

The Chinook types occur along the eastern slopes of the Rockies in the western portions of the Northwest and Southern Plains Regions. They cause extreme fire danger for short periods of time. The Pacific Chinook occurrence outweighs the Canadian by about 4 to 1.

Tropical storms sometimes cause high fire danger in the area beyond the rain shield, but so few occurred that statistics were not determined for them.

Regions West of the Rockies

Northern Rockies and Northern Intermountain Region.--Two surface types affect this region: the Pacific and the Northwest Canadian Highs. Critical fire weather occurs only in their pre-frontal and post-frontal quadrants. Peaks in critical burning periods frequently occur during dry frontal passages. The presence of a thermal trough just to the west of the High enhances the flow of dry southerly surface winds around the south side of the high pressure area. The steepness of the upper-air ridge determines whether or not a Northwest Canadian High will affect this region. And the direction of the upper-air flow is the principal difference between the two fire-weather types.

Central Intermountain Region.--Upper-air flow is more significant in this region. There are three critical fire-weather types. One, an upper-air pattern, is the Meridional Ridge-Southwest Flow type; the other two types are combinations of an upper-air pattern and a surface Pacific High type. The principal difference between these two types is the direction of the upper-air flow. The stations affected in the Meridional Ridge-Southwest Flow type are under the west side of the upper ridge. In the other two types--the Pacific High-Meridional Flow and the Pacific High-Zonal Flow--the direction of the upper-air flow is northwesterly in the meridional type, while in the Zonal type the upper flow changes only slightly in direction as small amplitude waves pass by. Dry frontal passages at the surface cause peaks of relatively short duration in fire danger.

Southwest Region.--The three critical fire-weather types in the Southwest Region are the Meridional Ridge-Southwest Flow, the Short Wave Train, and the Zonal Ridge types. All three are identified on upper-air charts because the surface pressure patterns are poorly defined. The Short Wave Train pattern is quite similar to the Meridional Ridge-Southwest Flow type except that the amplitude and wave length in the "Train" pattern are much smaller. Well developed short waves are carried in the belt of westerlies through the long-wave pattern exerting their effect on fire danger by increasing wind velocities. All three types have the common characteristics of a ridge to the east and trough to the west of

the affected area. The Zonal Ridge type, however, is an extremely flat pattern with small changes in wind direction aloft.

Pacific Northwest Region.--Critical fire weather in the Pacific Northwest occurs only when flow is offshore and strong enough to force the marine air off the coast. Dry East or Northeast winds of continental origin are responsible for high fire danger. Offshore flow occurs in both Pacific and Northwest Canadian air masses, but the Pacific High type is by far the most frequent.

California Regions.--The critical fire-weather types of northern and southern California were similar and therefore the two regions were combined. Four weather types are significant--two are upper-air and two are surface types. The upper-air patterns are the Subtropical High Aloft and the Meridional Ridge-Southwest Flow. The Subtropical High is a stagnant pattern which blocks moisture from the Gulf of Mexico. Maximum temperatures are high and humidities correspondingly low. The Meridional Ridge-Southwest Flow pattern usually brings marine air and low fire danger in the coastal areas, but the higher stations and interior valleys are adversely affected by high winds when frontal passages occur to the north, tightening pressure gradients.

The Pacific High Post-Frontal and Great Basin High types produce the well-known foehn winds and their associated extreme fire danger. The combined effects of high winds and dry air produced by these weather types bring about rapid changes in burning conditions. They cause extreme fire weather which is unparalleled anywhere else in the United States.

Processing The Data

The raw data were placed on punchcards and processed on IBM 1620 and 7094 computers. The program produced statistics by station, month, and weather type. The statistics comprise the bulk of this report and are grouped both by region and station, and by critical fire-weather type. They have been published separately in the form of supplements.

RESULTS

The results of the study consist primarily of the statistics themselves. A summary of the frequency and duration of each of the major synoptic types was recorded separately in a series of tables. Statistics on weather parameters and fire danger indexes for each type were recorded for each of the 89 individual stations.

APPLICATIONS

The statistical form of this report leaves wide latitude for applying the results. We have identified three broad areas in which the results can be readily applied. The first two, fire weather forecasting

and fire control planning, are operational areas; the third area, weather and fire phenomena, can be of immediate concern to the researcher who is seeking to improve his understanding of the fire problem.. We recognize the limitations of probability forecasting based on climatological data such as those included in this report, but the fact remains that we do have now a basis upon which a quantitative probability forecast for a particular event can be made. Because of the variability between years in the occurrence of each of the critical fire-weather types, the forecaster will not be relieved of the necessity of predicting the event based on present methods. These data will, however, give him a quantitative idea of what the odds are, based on climatology. The data will also be useful to a forecaster in other meaningful ways. For example, he will be able to compare one type or quadrant to another and determine how the various weather parameters change relative to one another. In this comparison he can determine which types are worse than others, and by how much, and in which months, etc.,

Long range planning can be effectively carried out by fire control agencies by using the data in much the same way as the forecaster uses them. Assessing the relative potential of each fire weather type in each location should be most advantageous. Just knowing the relative differences between critical fire-weather types by months gives the fire control planner a way of quantitatively rating one area against another for any particular month in the year. By extending the statistics reported here to other stations, probability forecasts could be refined for local fire-weather areas.

CONCLUSIONS

1. Fire danger is not always high when one of the critical fire-weather types occurs; therefore the forecaster must still assess the weather situation for precipitation, temperature, and past weather since these factors cannot be readily interpreted from the synoptic charts themselves.

2. If applied intelligently, the statistics can be used effectively as an aid in forecasting specific values of several weather parameters.

3. Fire control planners should find the statistics helpful in developing long range fire plans.